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(19) (CA) **CANADIAN PATENT** (12)

(54) Multi-Element Electrosurgical Indifferent Electrode with Temperature Balancing Resistors

(72) Frize, Monique;
Leduc, Andre;
Poussart, Yves,
Canada

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ABSTRACT OF THE DISCLOSURE

An electro surgical electrode is disclosed for attachment to a patient's skin. The electrode is segmented and arranged to control the current passing through each segment to avoid high temperatures at certain contact areas. The electrode comprises a plurality of separate conductive elements spaced apart in a surface plane and attached to a non-conductive backing, a connector from each one of the conductive elements to a resistor having a resistance value proportional to current flow through the one of the conductive elements to provide uniform current distribution and attachment means for attaching the conductive elements to a patient's skin.

The present invention relates to electrosurgical dispersive electrodes. More specifically, the present invention relates to an electrode for attachment to a patient's skin with connections to an electrosurgical generator.

Electrosurgical dispersive electrodes available on the market today take many shapes, forms and sizes. Such electrodes are used to return current from a patient's skin to an electrosurgical generator during electro surgery which involves cutting, coagulation or a blend of these two techniques. Electrosurgical electrodes must have good adhesive quality to stick to the skin and to stay on the skin during the entire surgery process. The distribution of current flow through the conductive surface of the electrode is a factor which relates to the temperature rise under the electrode. It has been found that current flow is generally not uniform and therefore hot areas occur on a patient's skin under the conductive surface of the electrode. Many electrodes use gel, mostly a high conductive gel, however some of these gels tend to migrate, that is to say move so that an uneven thickness of gel occurs across the conductive surface which again leads to a non-uniform temperature on the patient's skin. Gel also can migrate to the adhesive portion of the electrode which reduces the adhesive properties, often resulting in the electrode not properly contacting the patient's skin.

Most electrodes presently available on the market today are constructed of an insulating material on which a metallic surface has been attached. In some cases the electrodes have gel which covers the metallic surface. The peripheral portion of the electrodes where there is no gel usually contains an adhesive material which holds the electrode to the patient's skin. Some electrodes use a conductive adhesive gel throughout their entire surface area. In some cases, gel is applied to a dry metal surface on the conductive

area just before attaching the electrode to the patient's skin.

It has been found that a higher current occurs at the outer periphery of the conductive surface on the electrode and this is where heat is produced on the skin. The result is a substantially higher temperature at this peripheral edge which can in certain circumstances cause a burn on the patient's skin.

One electrode design available on the market today is made of a dry non-conductive material, usually a gauze or a foam type material under which is a conductive metallic surface. The peripheral portion of the electrode consists of an adhesive material and the current returns via a capacitive coupling and is distributed more uniformly over the entire surface area of the patient. The electrode field between the electrode and the patient is more uniform than with other types of electrodes. However this electrode contains an inherent hazard: if a small hole or pinhole defect occurs in the electrode surface, then the current can concentrate at this spot and cause a burn on the patient's skin.

We have found that these problems of varying heat from the surface area of an electrosurgical electrode can be overcome by providing divided sections of conductive surface, each section being connected to a separate resistor whose value determines the proportion of current allowed to flow through it. By choosing different resistance values, the current may be distributed more evenly throughout the entire electrode conductive surface. This electrode requires the sections to be spaced apart a sufficient amount to avoid problems occurring with short circuiting across adjacent sections, as this defeats the purpose of dividing the conductive surface into different sections.

It is an object of the present invention to provide an electrosurgical electrode with a uniform current distribution and therefore a uniform heat distribution over the conductive surface of the electrode. It is a further

object to produce an electrode that provides both a lower current density and a lower heat density at the contact with the patient's skin than present designs of electrosurgical electrodes.

The present invention provides an electrode for connection to an electrosurgical generator comprising: a plurality of separate conductive elements spaced apart in a surface plane and attached to a non-conductive backing, a connector from each one of the conductive elements to a resistor having a resistance value proportional to current flow through the one of the conductive elements to provide uniform current distribution, and attachment means for attaching the conductive elements to a patient's skin.

In other embodiments of the invention, a gel coating is included on the conductive elements, the gel coating having a high resistivity. The conductive elements in another embodiment are in the form of a plurality of concentric rings about a circular disc, with the disc and each of the rings being connected to individual resistors having different resistance values, such that current density per skin surface contact area is substantially the same for the disc and the rings. In a preferred embodiment each of the resistors for the concentric rings on the outside has a higher resistance value than the resistors for the concentric rings on the inside and the disc. Preferably the conductive elements each have a resistor with a resistance value not greater than about 50 ohms. In another embodiment, the conductive elements are in the form of parallel strips with a spacing of at least about 2 mm provided between the strips. The gel coating preferably has a gel resistivity in the range of about 500 to 1,000 ohm-centimetres. In a still further embodiment, the electrode and connectors include a short cable and polarized connector plug which are all disposable, the connector plug is adapted to mate with a socket having connections to the resistors and electrosurgical generator.

In yet a further embodiment, the circular disc

has a connector link in the same plane as the skin surface contact area extending off to one side, and wherein each of the concentric rings has a peripheral gap and a connector link in the same plane as the skin surface extending off to the one side, wherein the connector links from the disc and each ring are substantially parallel to each other and extend off to the one side through the peripheral gaps in adjacent larger concentric rings. A shorting pad may be provided adjacent the connectors, adapted to cooperate with a separate continuity connector to indicate a completed connection between the electrode and the electrosurgical generator.

In other embodiments, the non conductive backing is a plastic sheet and the attachment means includes an adhesive material contained in a peripheral portion surrounding the conductive elements. The non conductive gaps between conductive elements may also have adhesive material therein or alternatively the gel coating may be an adhesive gel to form the attachment means, the adhesive gel having a high resistivity.

In drawings which illustrate embodiments of the invention,

Fig. 1 is a schematic perspective view of a patient having an electrode of the present invention attached to a thigh and connected to an electrosurgical generator.

Fig. 2 is a schematic view of an electrode of the present invention with a polarized connector plug for connection to a socket.

Figs. 3, 4 and 5 are plan views showing different embodiments of electrodes according to the present invention.

Fig. 1 illustrates the use of an electrode for electrosurgery and shows a patient 10 having an electrode 11 attached to a thigh. A multiple cable 12 connects the different elements of the electrode 11 to a polarized connector plug 13 which in turn is connected to a socket 14 having a permanent cable 15 leading to a resistor box 16.

The resistor box 16 has a connecting cable 17 leading to the electrosurgical generator 18. The resistor box 16 may form part of the electrosurgical generator 18. Upon completion of electrosurgery, the cable 12 together with electrode 11 and plug 13 are disposed of and not re-used whereas the socket 15 with the permanent cable 15 to the resistor box 16 can be used a number of times. The electrosurgical generator 18 is a conventional device comprising a high frequency current generating system including an RF oscillator which drives a gain controlled power amplifier that is coupled via a step-up transformer and coupling capacitors to the active electrode 19. The active electrode 19 may be in the form of a knife, scalpel or other implement dependent upon the particular type of electrosurgery being performed.

One example of the electrode 11 is shown in Fig. 2 having two concentric circular elements 20, 21 about a center circular element 22. The elements 20, 21 and 22 are mounted on a non-conductive circular backing 23 having a gap between each element and an exterior peripheral portion to which an adhesive is attached for securing the electrode 11 to a patient's skin. Three connector wires 24 from the three elements 20, 21 and 22 pass through the cable 12 to the polarized connector plug 13 having three prongs 25 which engage with sockets 26 in the plug 14. Resistors 27 in the resistor box 16 have a predetermined resistance value for a particular element 20, 21 and 22. Beyond the three resistances 27, the wires are connected together to have one lead in the cable 17 to the electrosurgical generator 18. A second lead may be included in the cable 17 as a continuity check between the electrode and the generator 18. The resistance value is determined so as to have uniform temperature distribution and this is obtained by having uniform current density per skin surface contact area for the electrode 11. The surface area of each element is determined and then the portion of the total current to each element is calculated. With this

figure, the resistance value for each resistor 27 is determined. It is preferable that the values of these resistors do not exceed 50 ohms, however the resistance values are determined for use with a gel having a known resistance. A 50 ohm resistivity would would be suitable with a gel having a resistivity in the range of about 500 to 1,000 ohm centimetres.

As current normally flows at the periphery of the electrodes, the resistors for the outer rings have a higher resistance value than those in the center. This forces the current to be distributed more evenly throughout the entire conductive surface of the electrode. The rings are separated by a gap which is normally at least about 2 mm in width. The gap is sufficient for the resistor circuit to be effective and to prevent short circuiting of the three elements 20, 21 and 22.

Figs. 3 and 4 illustrate electrodes 11 with concentric elements. Fig. 3 has a center circular disc 30 having a connector link 31 to a connector tab 32. An intermediate concentric ring element 33 has a peripheral gap 34 for passage of the connector link 31 from the disc 30 and has a second connector link 35 to the connector tab 32. An outside concentric ring element 36 has a further peripheral gap 37 for the two connector links 31 and 35 and a third connector link 38 to the connector tab 32. The connector links 31, 35 and 38 are substantially parallel and all lead out to one side of the electrode passing through the peripheral gaps 34 and 37. The elements 30, 33 and 36 are all in the same plane and have gaps between each other of about 2 mm. The elements are mounted on a non-conductive backing material 39 which has a peripheral portion 40 containing an adhesive material. The backing material 39 may be foam, plastic, fabric, or other suitable sheet material that is non-conductive. The adhesive which is preferably non-conductive, extends across the connector tab 32 to ensure that the connector links 31, 35

and 38 are not in contact with the skin surface.

A similar embodiment is shown in Fig. 4 with a center circular disc 30 and five concentric ring elements 42 extending out from the element with connector links 43 to a connector tab 32. The embodiments shown in Fig. 3 has a diameter of approximately 9 centimetres whereas the diameter of the electrode shown in Fig. 4 is approximately 16 centimetres. The smaller unit shown in Fig. 3 is designed as a pediatric model, whereas the larger unit is for adult applications. The conductive medium for the elements is a metallic sheet such as aluminum, stainless steel, copper or other suitable material. A non-metallic conductive sheet material may also be applicable with a thickness in the order of approximately 1 mil mounted on a suitable non-conductive backing sheet. As shown, the tab 32 has a shorting pad 44 for connection to a continuity circuit. This shorting pad 44 completes a check circuit between the electrode and the generator to indicate that the system is properly connected. Whereas two embodiments are shown herein, it will be understood that other electrodes having a different number of ring elements may be produced dependent upon the particular requirement of the electrode.

In a preferred embodiment, a coating of gel is placed on the conductive surfaces of the electrode. The gel cannot be highly conductive as compared to metal or a saline solution, otherwise short circuiting occurs between adjacent elements which defeats the purpose of the electrode. A gel with a higher resistivity is required. A gel having a resistance in the range of about 500 to 1,000 ohm-centimetres is appropriate as it has a higher value than the resistors used to control the flow of current through the different elements and therefore has minimal influence on the current flowing ability of the electrode. This higher resistivity gel provides a better patient electrode contact and an intermediate impedance value that contributes to a more uniform electrical field between the patient's skin and the electrode.

One type of gel that has been found suitable is a purified agar gel in solid form. The gel unlike those made with a bacteriological grade of agar is highly resistive thus providing ideal resistivity between the skin and the electrode and avoiding short circuiting that could occur with a normal gel which would result in non-uniform current distribution.

Whereas an adhesive is attached to the peripheral portion 40 of the backing material, in some cases adhesive may be included in the gaps between the elements to ensure good contact and to maintain the conductive surface of the electrode on the patient's skin. In another embodiment, an adhesive gel may be utilized across the surface of the electrode including the surface of the conductive elements, however such a gel must have high resistivity to prevent short circuiting.

Fig. 5 illustrates a rectangular shaped electrode 11 having parallel strip elements 60 with small gaps therebetween. Each element 60 is attached by a connector link 61 to form the main cable 12.

Various changes may be made to the embodiments shown without departing from the scope of the present invention which is limited only by the following claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1) An electrode for connection to an electrosurgical generator comprising:

a plurality of separate conductive elements spaced apart in a surface plane and attached to a non-conductive backing,

a connector from each one of the conductive elements to a resistor having a resistance value proportional to current flow through the one of the conductive elements to provide uniform current distribution, and

attachment means for attaching the conductive elements to a patient's skin.

2) The electrode according to claim 1 including a gel coating on the conductive elements, the gel coating having a high resistivity.

3) The electrode according to claim 1 wherein the conductive elements are in the form of a plurality of concentric rings about a circular disc, with the disc and each of the rings being connected to individual resistors having different resistor values, such that current density per skin surface contact area is substantially the same for the disc and the rings.

4) The electrode according to claim 3 wherein each of the resistors for the concentric rings on the outside has a higher resistance value than the resistors for the concentric rings on the inside and the disc.

5) The electrode according to claim 3 or claim 4 including a spacing between the rings of at least about 2 mm.

6) The electrode according to any of claims 1, 2 or 3 wherein the conductive elements each have a resistor with a resistance value not greater than about 50 ohms.

7) The electrode according to claim 3 or claim 4 wherein the circular disc has a connector link in the same plane as the skin surface contact area extending off to one side, and wherein each of the concentric rings has a peripheral gap and a connector link in the same plane as the skin surface extending off to the one side, wherein the connector links from the disc and each ring are substantially parallel to each other and extend off to the one side through the peripheral gaps in adjacent larger concentric rings.

8) The electrode according to claim 1 or claim 2 wherein the conductive elements are in the form of parallel strips with a spacing of at least about 2 mm between the strips.

9) The electrode according to any of claims 1, 2 and 3 including a shorting pad adjacent the connectors, the shorting pad adapted to cooperate with a separate continuity connector to indicate a completed connection between the electrode and the electrosurgical generator.

10) The electrode according to claim 2 wherein the gel coating has a gel resistivity in the range of about 500 to 1,000 ohm-centimetres.

11) The electrode according to claim 2 wherein the gel coating is a purified agar solid gel having a resistivity in the range of about 500 to 1,000 ohm-centimetres.

12) The electrode according to any of claims 1, 2 or 3 wherein the electrode and connectors include a short cable and polarized connector plug which are all disposable, the connector plug adapted to mate with a socket having connections to the resistors and electrosurgical generator.

13) The electrode according to claim 1 wherein the attachment means includes an adhesive material contained in a peripheral portion surrounding the conductive elements.

14) The electrode according to claim ~~12~~ 13 including non-conductive gaps between conductive elements having adhesive material therein.

15) The electrode according to claim 2 wherein the gel coating comprises an adhesive gel to form the attachment means, the adhesive gel having a high resistivity.

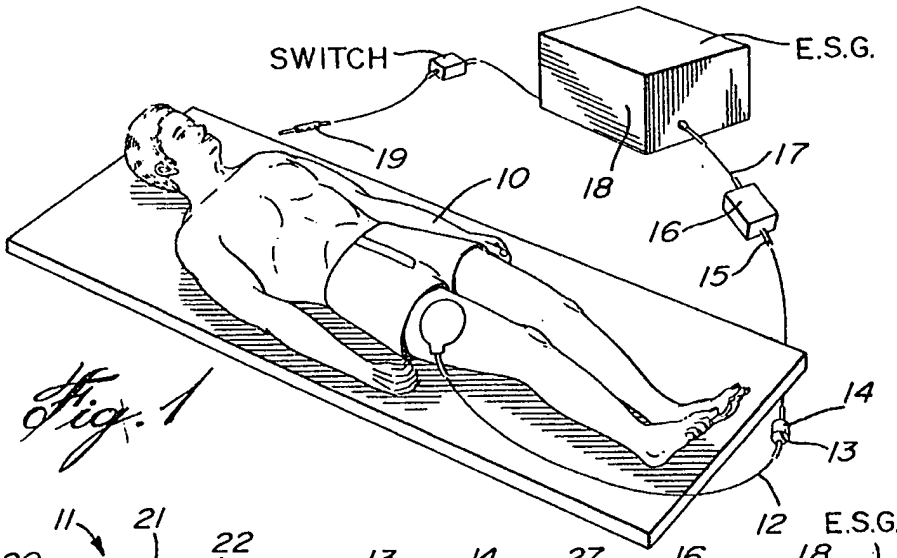

Fig. 1

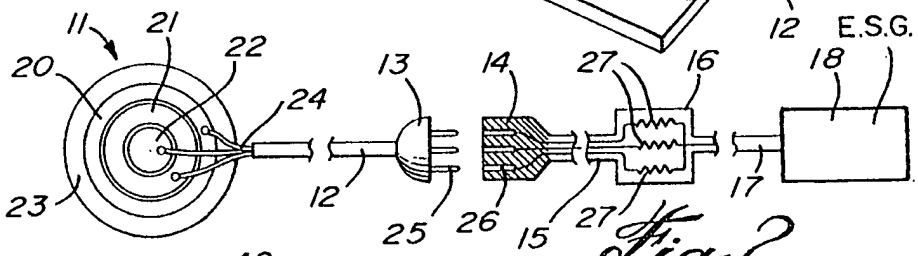

Fig. 2

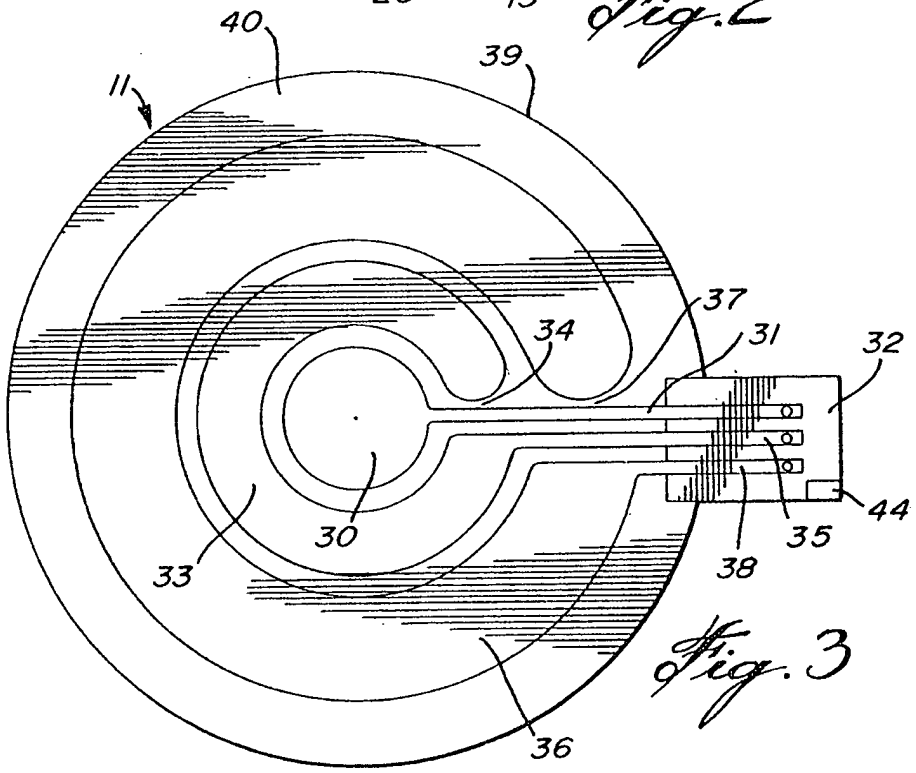

Fig. 3

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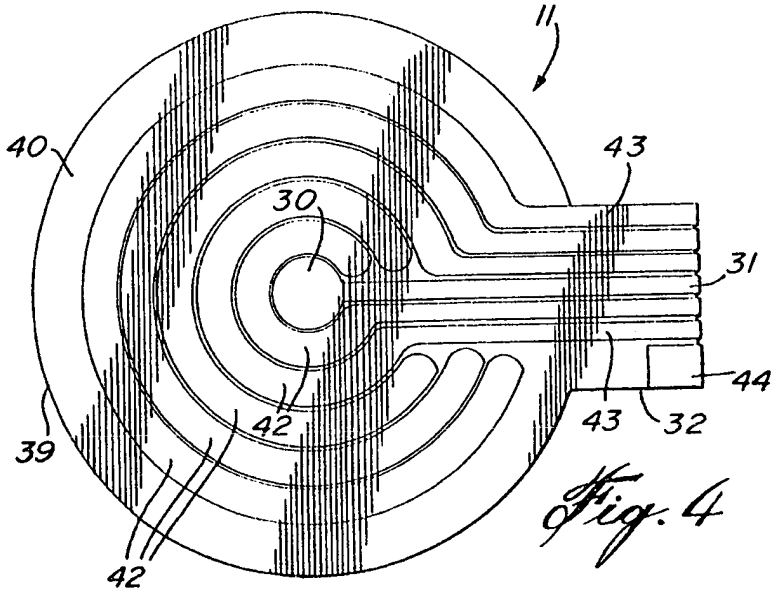

Fig. 4

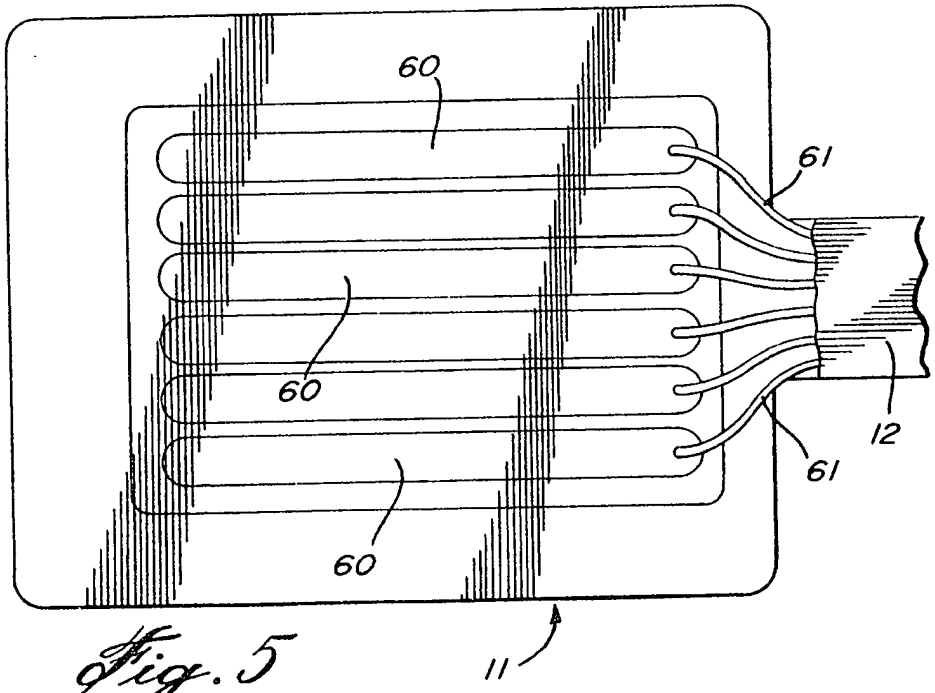

Fig. 5

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